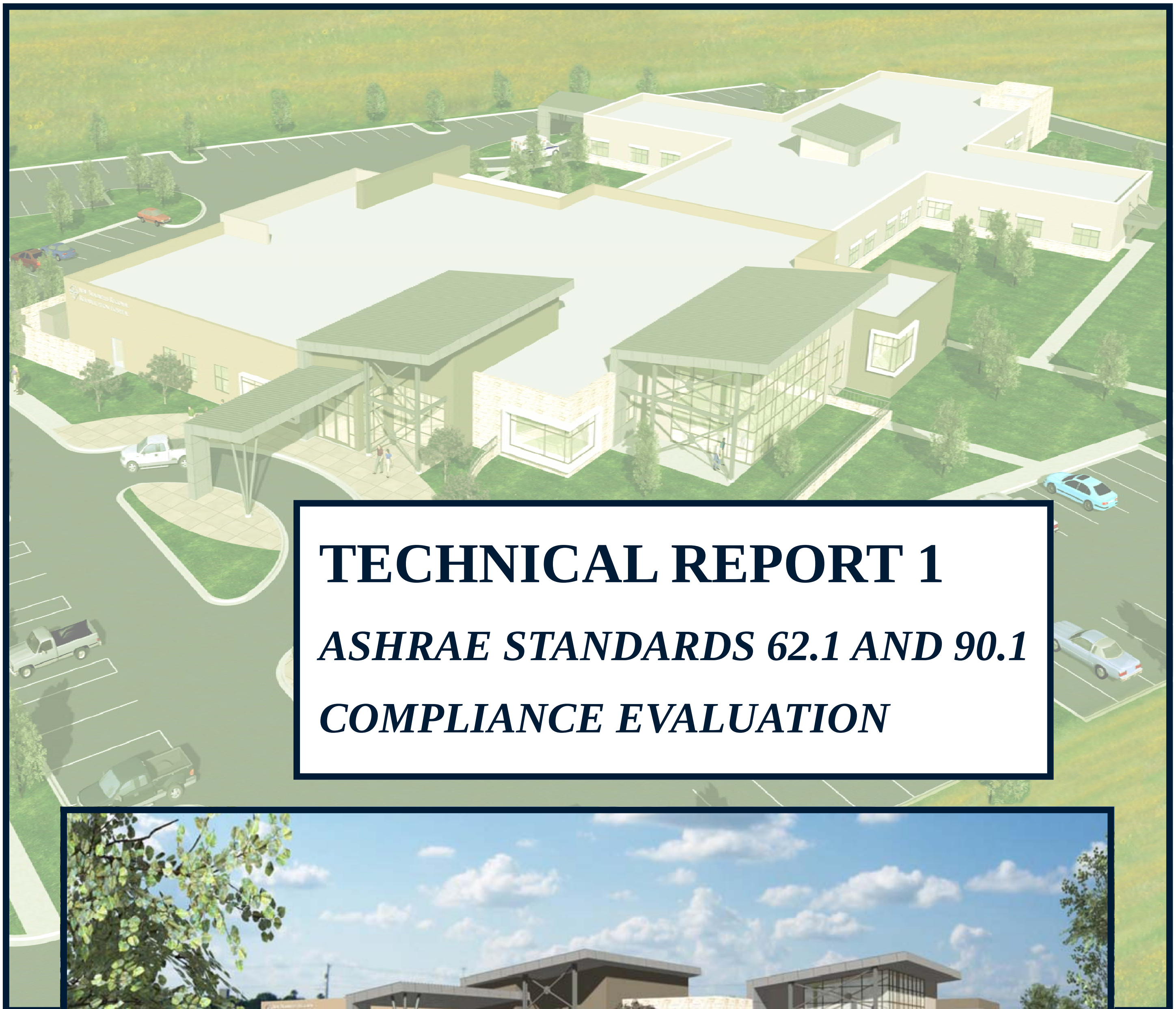

TECHNICAL REPORT 1

ASHRAE STANDARDS 62.1 AND 90.1 COMPLIANCE EVALUATION

New Braunfels Regional Rehabilitation Hospital

New Braunfels, TX

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Date Submitted: 9/23/11

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(1.0) Executive Summary

This report investigates the compliance of the New Braunfels Regional Rehabilitation Hospital (NBRRH) with *ASHRAE Standard 62.1-2007: Ventilation for Acceptable Indoor Air Quality* and *ASHRAE Standard 90.-20071: Energy Standard for Buildings Except Low-Rise Residential Buildings.*

The New Braunfels Regional Rehabilitation Hospital is an acute care hospital and physical therapy center with several critical space functions, which demand a sophisticated HVAC system. For this reason, *ASHRAE Standard 170: Ventilation of Health Care Facilities* was also investigated in areas where it was deemed that Standard 62.1 was insufficient.

An evaluation of ASHRAE Standard 62.1 showed that NBRRH is entirely compliant with Sections 5 and 6 of the standard, which specify requirements for indoor air environment and ventilation rates. A detailed ventilation rate analysis shows that each system satisfies Standard 62.1 requirements.

The facility also almost completely complies with Standard 170. Only a small percentage of the rooms were deemed to be non-compliant by an air-change rate analysis. Even with these more stringent ventilation and air-change-rate requirements, the systems serving patient room areas were determined to still comply with ASHRAE Standard 62.1.

NBRRH was determined to not be entirely compliant with ASHRAE Standard 90.1. Several requirements, such as maximum shading coefficients of glazing systems, power distribution design characteristics, and minimum lighting power densities were not met by the facility. A possible reason for not meeting these requirements could be that occupant health and safety was considered more highly for this building, and the budget may not have allowed for more sophisticated systems to meet those needs and comply with Standard 90.1.

Several aspects of the mechanical system design, as discussed in this report, show the responsible design practices used. Although the building does not comply with Standard 90.1 and did not strive for any type of energy certification, various design elements exceed the minimum requirements of 90.1.

It was determined through this analysis that the mechanical system design of the New Braunfels Regional Rehabilitation Hospital is satisfactory in providing occupant health and comfort while complying with required ventilation rates and striving for an environmentally-conscious design.

(2.0) Building Overview

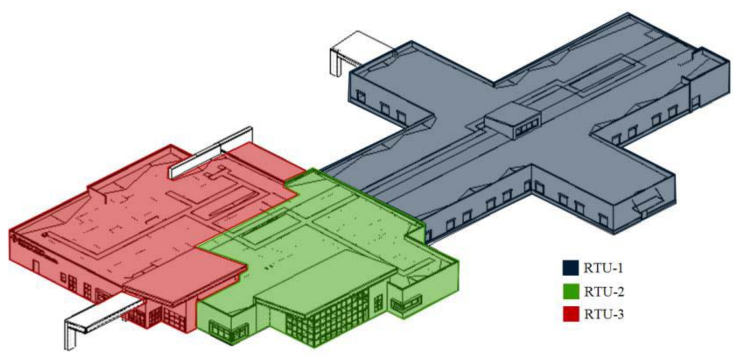
Facility Description

The New Braunfels Regional Rehabilitation Hospital is a 40-bed, acute-care hospital and physical rehabilitation clinic located about 30 miles northeast of San Antonio, Texas. Occupied by Ernest Health, Inc., the nearly 50,000 square foot facility is located on what was previously the Sundance Golf Club. Ernest Health operates 14 similar acute-care hospitals in various regions of the United States.

The hospital sits on a several hundred thousand square foot tract of land with no adjacent buildings, though there is a fairly large retaining pond across the street. A birds-eye view of the site before the facility was built and a plan view of after the facility was built can be seen in the images below.

Images courtesy of bing.com

Mechanical System Overview



Three packaged rooftop units supply most of the facility with conditioned air. Each of these units utilizes DX cooling and gas-fired heating. A graphical representation of what areas each unit serves is shown in the figure to the right. RTU-1 serves the patient-room wing of the facility, while RTUs 2 and 3 serve the patient therapy and dining/administration portions of the building, respectively.

Conditioned air is distributed to VAV terminal units serving each zone. These units contain reheat coils that are served by two gas-fired boilers in the south mechanical room. The entire facility uses a fully-ducted return system.

A therapy pool, located in the area served by RTU-2, uses a specialized pool dehumidification system to control indoor environmental quality in the pool area while maintaining proper pool temperatures. Additionally, a 100% outdoor air makeup air unit serves the kitchen and dining functions in the area served by RTU-3.

(3.0) ASHRAE Standard 62.1 Compliance Evaluation

ASHRAE Standard 62.1 – 2007 addresses ventilation requirements for acceptable indoor air quality. This standard, while comprehensive for many building applications, was considered insufficient for an analysis of a health care facility. For this particular compliance evaluation, *ASHRAE Standard 170 – 2008: Ventilation of Health Care Facilities* was used in areas where Standard 62.1 was deemed insufficient. Such areas are explicitly stated in this report.

(3.1) Section 5: Systems and Equipment

Section 5.1: Natural Ventilation

For purposes of occupant safety, all windows in the facility are inoperable. Natural ventilation was not used in this facility due to the complex ventilation requirements of hospitals, thus Section 5.1 is not applicable to this analysis.

Section 5.2: Ventilation and Air Distribution

VAV terminal units have fixed outdoor air damper positions that comply with the minimum required ventilation airflow for each space as defined by Section 6 of Standard 62.1, which is discussed later in this report. The mechanical system design utilizes fully-ducted supply and return air, so the ventilation system is not affected by issues common to a plenum air distribution system.

Section 5.3: Exhaust Duct Location

All exhaust ducts are specified to be negatively pressurized and operate at a SMACNA -4.0" w.g. static pressure class so that potentially harmful exhaust air cannot leak into the plenum space. The maximum velocity of these exhaust ducts is specified to be 4000 FPM.

Duct and seam and joint construction, sheet metal thicknesses, and hangars and supports for all ductwork, including exhaust, are specified to comply with SMACNA's *HVAC Duct Construction Standards – Metal and Flexible."*

Section 5.4: Ventilation System Controls

The outdoor and return air dampers are controlled by a modulating, spring-return actuator within the air handling units. The outdoor air dampers modulate in response to the unit's temperature control system. An adjustable enthalpy control is also included in the units to monitor the outdoor air's dry-bulb temperature and relative humidity. If the outdoor air is deemed suitable, free-cooling can be achieved via the position of the outdoor air dampers.

Section 7.2.2 of ASHRAE Standard 170 establishes that protective environment (PE) rooms must maintain proper pressurization levels. In this facility, airflow to each patient room is regulated by a differential pressure sensor, ensuring that the patient rooms are always positively pressurized in relation to the attached toilet room and corridor. Although these patient rooms are not classified as PE rooms, this control system is safe practice and is in compliance with Section 7 of Standard 170.

Section 5.5: Airstream Surfaces

Interior duct lining is specified to be coated with an antimicrobial, erosion-resistant coating. This also acts as a moisture repellant, prohibiting mold growth along the airstream. This antimicrobial compound is tested for efficacy in HVAC systems by a nationally recognized testing laboratory registered by the EPA.

The solvent-based adhesive for this coating complies with NFPA 90 and ASTM C 916 and has a VOC content of less than 80 g/L. This adhesive also complies with the requirements of *Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers*, printed by the Texas Department of Health Services.

Section 5.6: Outdoor Air Intakes

All outdoor air intakes are located such that the minimum distance to any potential air-contaminating source complies with Table 5-1 of Standard 62.1, shown below in Figure 1 below.

Object	Minimum Distance, ft (m)
Significantly contaminated exhaust (Note 1)	15 (5)
Noxious or dangerous exhaust (Notes 2 and 3)	30 (10)
Vents, chimneys, and flues from combustion appliances and equipment (Note 4)	15 (5)
Garage entry, automobile loading area, or drive-in queue (Note 5)	15 (5)
Truck loading area or dock, bus parking/idling area (Note 5)	25 (7.5)
Driveway, street, or parking place (Note 5)	5 (1.5)
Thoroughfare with high traffic volume	25 (7.5)
Roof, landscaped grade, or other surface directly below intake (Notes 6 and 7)	1 (0.30)
Garbage storage/pick-up area, dumpsters	15 (5)
Cooling tower intake or basin	15 (5)
Cooling tower exhaust	25 (7.5)

Note 1: Significantly contaminated exhaust is exhaust air with significant contaminant concentration, significant sensory-irritation intensity, or offensive odor.
Note 2: Laboratory fume hood exhaust air outlets shall be in compliance with NFPA 45-1991[3] and ANSI/AIHA Z9.5-1992.[4]
Note 3: Noxious or dangerous exhaust is exhaust air with highly objectionable fumes or gases and/or exhaust air with potentially dangerous particles, bioaerosols, or gases at concentrations high enough to be considered harmful. Information on separation criteria for industrial environments can be found in the ACGIH Industrial Ventilation Manual[5] and in the *ASHRAE Handbook—HVAC Applications*.[6]
Note 4: Shorter separation distances are permitted when determined in accordance with (a) Chapter 7 of ANSI Z223.1/NFPA 54-2002[7] for fuel gas burning appliances and equipment, (b) Chapter 6 of NFPA 31-2001[8] for oil burning appliances and equipment, or (c) Chapter 7 of NFPA 211-2003[9] for other combustion appliances and equipment.
Note 5: Distance measured to closest place that vehicle exhaust is likely to be located.
Note 6: No minimum separation distance applies to surfaces that are sloped more than 45 degrees from horizontal or that are less than 1 in. (3 cm) wide.
Note 7: Where snow accumulation is expected, distance listed shall be increased by the expected average snow depth.

Figure 1 – Air Intake Minimum Separation Distance

Specifically, all outdoor air intakes for the rooftop air handling units are located more than 30 feet from any rooftop exhaust fan. Similarly, the air intake for the 100% outdoor air makeup air unit serving the kitchen is located over 30 feet from all kitchen exhaust fans.

All intake and exhaust ductwork are pitched for rain water runoff per SMACNA guidelines and are provided with support rails and galvanized bird screen hoods.

Section 6.3 of ASHRAE Standard 170 requires outdoor air intakes to be a minimum of 25 feet from cooling towers and all discharge air vents for units serving health-care functions. RTU-1 complies with this more stringent requirement, as stated above.

Section 5.7: Local Capture of Contaminants

None of the non-combustion equipment in the facility produces contaminants, so Section 5.7 does not apply to this analysis.

Section 5.8: Combustion Air

All fuel-burning rooftop units are not enclosed, and thus have the necessary available combustion air needed for proper operation. The gas-fired, non-condensing boilers located in the mechanical room are served by a 48” x 16” combustion air intake louver, which provides adequate combustion air, according to the manufacturer’s product data. Adequate combustion air is provided to the gas-fired water heaters used to heat domestic hot water through sidewall inlets as specified by the manufacturer.

Section 5.9: Particulate Matter Removal

All outside air is pre-filtered through 2” MERV 7 filters and additionally filtered by 12” MERV 14 final filters before being supplied to the VAV terminal units. The filter media used is micro-glass fiber and the separator material is a thermoplastic resin spaced at 25 mm intervals. This draw-through air filtration sequence surpasses the required rating of MERV 6 prescribed in this section.

Section 6.4 of ASHRAE Standard 170 requires two filter banks: the first placed upstream of heating and cooling coils to filter mixed air, and the second downstream of all cooling coils and the supply fan. Both of these requirements are met in compliance with Standard 170, as shown in Figure 2 below.

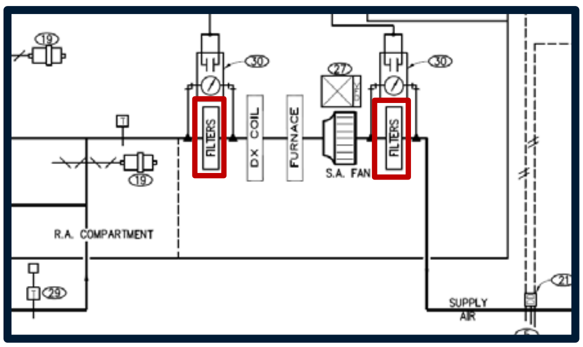


Figure 2 – Filter Locations

Section 5.10: Dehumidification Systems

Dehumidification for the majority of the facility is achieved using modulating hot gas reheat, which conditions air to less than 60% relative humidity, exceeding the requirements of this section.

A packaged dehumidification system is used to maintain occupant comfort and swimming pool environment in the therapy pool area. This unit recovers sensible and latent heat as needed to put back in the air or pool water. The unit is designed to maintain the room at 86ºF and 60% relative humidity while keeping the pool water at 80ºF.

Section 5.11: Drain Pans

Stainless steel drain pans are provided with the cooling coils on all rooftop units. Each pan has a minimum slope of 1/8” per foot to ensure positive draining. The pans are specified to be connected to a threaded drain connection that extends through the base of the unit. Each pan is specified to extend underneath the cooling coil connections and beyond the leaving side of the coil.

Section 5.12: Finned-Tube Coils and Heat Exchangers

Drain pans are specified to be installed beneath all mechanical dehumidification units, as noted in specification section 238416. No condensate-producing heat exchangers are used in the facility, so drain pans are not required for this application.

All equipment cooling coils have more than 18 inches of access space, and thus the required minimum pressure drop stated in Section 5.12.2 is not applicable to this project.

Section 5.13: Humidifiers and Water-Spray Systems

None of the equipment used in the building utilizes humidifiers or water-spray systems, so Section 5.13 is inapplicable in this evaluation.

Section 5.14: Access for Inspection, Cleaning, and Maintenance

Service doors are included on both sides of all sections of the rooftop air-handling units for maintenance purposes. A safety catch is provided in the latch system of each door to protect against injury if the door is opened during fan operation.

Air distribution equipment within the building is located above a lay-in ceiling so maintenance personnel can easily access equipment for cleaning and repairs.

Section 5.15: Building Envelope and Interior Surfaces

All exterior surfaces in the building contain a layer of moisture protection. Exterior walls have a ⅝” thick WPC sheathing and all roof types contain a ¼” thick TPO membrane, in compliance with Section 5.15.1 of Standard 62.1.

Specification section 230700 notes requirements for HVAC insulation to prevent condensation from occurring on exterior duct surfaces, in order to comply with Section 5.15.2 of this standard.

Section 5.16: Buildings with Attached Parking Garages

Parking for the rehabilitation hospital is not attached to the facility, so Section 5.16 is not explored in this evaluation.

Section 5.17: Air Classification and Recirculation

All air in the areas served by RTU-2 and RTU-3, other than in the kitchen and restrooms, is classified as Class 1 air, and can thus be recirculated to any space. Air in the kitchen and restrooms are exhausted straight out of the building and are not recirculated, so the air classification of these spaces is inconsequential.

Air in the area served by RTU-1, including patient and treatment rooms, is classified as Class 2 air, which may be recirculated to other areas with a Class 2 air classification. Exhaust air from the toilet rooms in this area is taken straight out of the building, so the classification of this air was not considered.

Section 5.18: Requirements for Buildings Containing ETS Areas

As a health care facility, the New Braunfels Regional Rehabilitation Hospital does not have any environmental tobacco smoke areas, so Section 5.18 is not applicable to this facility.

Additional Requirements of ASHRAE Standard 170

In accordance with Section 6.1.1 of Standard 170, all patient rooms must maintain the ventilation requirements stated in Section 3.2.1 of this report upon loss of electrical power. This requirement is noted in the electrical specification section 230900.

(3.2) Section 6: Procedures

Section 6 of ASHRAE 62.1 outlines a ventilation rate procedure to determine the minimum outdoor ventilation air required for a system based on the occupancy distribution and type as well as zone size. Other factors taken into account in a ventilation analysis prescribed by this standard are zone air distribution effectiveness and the primary outdoor air fraction.

ASHRAE Standard 170 was used in conjunction with 62.1 to determine the ventilation air required for the rooftop unit serving the patient rooms in the facility. Standard 170 outlines an air changes per hour procedure based on individual room function and volume.

(3.2.1) Ventilation Rate Procedure

The equation used to calculate the breathing zone outdoor airflow (V_{bz}) for each zone is given by Equation 6-1 in Standard 62.1, shown below.

$$V_{bz} = \left(R_p \cdot P_z\right) + \left(R_a \cdot A_z\right)$$

where R_p = outdoor airflow rate required per person (from Table 6-1)
R_a = outdoor airflow rate required per unit area (from Table 6-1)
P_z = largest number of people expected to occupy that zone
A_z = net floor area of the zone

The zone air distribution effectiveness (E_z) of the distribution system is determined to be 1.0, in accordance with Table 6-2 of Standard 62.1. Thus the Zone Outdoor Airflow (V_{oz}) is the same as V_{bz}, given by Equation 6-2 of Standard 62.1, shown below.

$$V_{oz} = {}^{V_{bz}}/_{E_z}$$

The primary outdoor air fraction (Z_p) is the minimum percentage of supply air that is outdoor ventilation air, and is calculated by taking a ratio of zone outdoor airflow to the zone primary airflow (V_{pz}), as shown in Equation 6-5 of Standard 62.1 on the following page.

$$Z_p = V_{oz}/V_{pz}$$

The total outdoor air intake is then determined to be the product of the primary outdoor air fraction and the total supply air used by the system.

Using this prescriptive procedure, the total ventilation rates of RTU-2 and RTU-3 were determined to be compliant with the minimum requirements given by Table 6-1 of Standard 62.1. Detailed calculations are shown in Tables A1 and A2 of Appendix A.

(3.2.2) Air Changes per Hour Procedure

An ASHRAE Standard 170 air changes per hour procedure was performed to determine the ventilation compliance of areas that 62.1 did not address. These spaces were primarily patient rooms, patient toilet rooms, medical gas storage, and other hospital-specific rooms.

To perform this compliance procedure, the volume of each room was calculated and used to convert the supply air CFM to air changes per hour and outdoor air changes per hour. For each room, these values were then compared to those given in Table 7-1 of Standard 170, a sample of which is shown below in Figure 3.

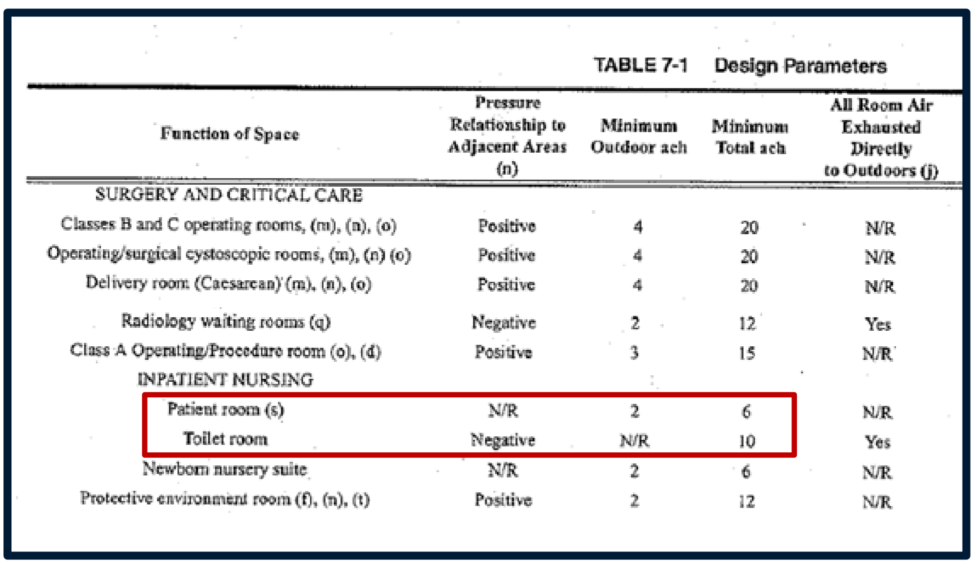


TABLE 7-1 Design Parameters

Function of Space	Pressure Relationship to Adjacent Areas (n)	Minimum Outdoor ach	Minimum Total ach	All Room Air Exhausted Directly to Outdoors (j)
SURGERY AND CRITICAL CARE				
Classes B and C operating rooms, (m), (n), (o)	Positive	4	20	N/R
Operating/surgical cystoscopic rooms, (m), (n) (o)	Positive	4	20	N/R
Delivery room (Caesarean) (m), (n), (o)	Positive	4	20	N/R
Radiology waiting rooms (q)	Negative	2	12	Yes
Class A Operating/Procedure room (o), (d)	Positive	3	15	N/R
INPATIENT NURSING				
Patient room (s)	N/R	2	6	N/R
Toilet room	Negative	N/R	10	Yes
Newborn nursery suite	N/R	2	6	N/R
Protective environment room (f), (n), (t)	Positive	2	12	N/R

Figure 3 – Example Air Change Rate Requirements

Each room was evaluated to determine if they met both air change requirements of Standard 170. 92 of the 105 rooms evaluated, including all patient rooms and toilet rooms, complied with these requirements. Areas that did not comply with these requirements included the hospital's public restrooms, medical gas storage, and linen storage rooms.

The minimum outdoor air change per hour calculated was then used, in conjunction with the Standard 62.1 analysis of the other rooms on the system, to determine the ventilation air requirements for RTU-1. It was found that, even with these more stringent requirements, the system as a whole still met the necessary ventilation rate outlined in Standard 62.1. A summary of calculations for RTU-1 is shown in Table A3 of Appendix A.

Results of both the prescriptive ventilation rate procedure and the air change per hour procedure are shown in Table 1 below.

Ventilation Compliance Summary					
System	ASHRAE 62.1			ASHRAE 170	
	OA Required	Minimum OA	Compliant?	% Rooms Compliant	Ventilation Compliant?
RTU-1	3730 CFM	6850 CFM	**Y**	88%	**Y**
RTU-2	1327 CFM	2015 CFM	**Y**	N/A	N/A
RTU-3	2314 CFM	4550 CFM	**Y**	N/A	N/A

Table 1 – Ventilation Compliance Summary

(3.3) Standard 62.1 Analysis Conclusions

This analysis has determined that the New Braunfels Regional Rehabilitation Hospital is completely compliant with ASHRAE Standard 62.1 – 2007. Several areas of the HVAC system design, such as humidity control and air filtration, well exceed the requirements put in place by this standard. On a system level, the amount of ventilation air supplied to the building exceeds what is required by 62.1.

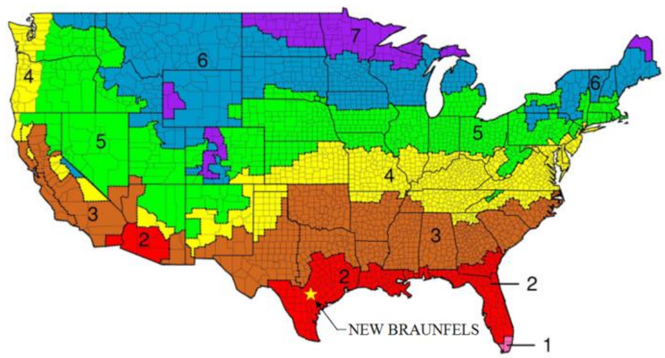
NBRRH is also very close to overall compliance with *ASHRAE Standard 170: Ventilation of Health Care Facilities*. An analysis of the patient room wing shows that this unit complies with Standard 62.1, even by the more stringent air changes per hour ventilation rate calculation. However, several individual rooms do not meet the necessary outdoor air change rate designated by Standard 170.

(4.0) ASHRAE Standard 90.1 Compliance Evaluation

ASHRAE Standard 90.1 is the energy standard for non-low rise, residential buildings. Though compliance with this standard is not required, the sections discussed in the standard should be considered for a responsible mechanical system design.

(4.1) Section 5: Building Envelope

The New Braunfels Regional Rehabilitation Hospital is located in climate zone 2A, defined by Table B-1 of ASHRAE Standard 90.1. This zone implies a hot, humid climate.



Because the facility has a 20.5% fenestration area, with no skylights, the prescriptive compliance path specified in Section 5.5 of Standard 90.1 can be followed. The building envelope requirements for climate zone 2 are outlined in Table 5.5-2 of the standard.

A summary of the building envelope characteristics is shown below in Table 2. All of the requirements for assembly maximum U-Values are met, though the solar heat gain coefficient (SHGC) of both the windows and the curtain wall system are higher than the maximum allowed SHGC in this standard.

Building Envelope Requirements Compliance						
Element	U-Value	Max. U-Value	SHGC	Max. SHGC	Compliance	
					U-Value	SHGC
Metal Deck Roof	0.03569	0.048	N/A	N/A	**Y**	N/A
Above-Grade Walls	0.05543	0.113	N/A	N/A	**Y**	N/A
4" HW Concrete Floor	0.6587	F = 0.730	N/A	N/A	**Y**	N/A
Windows	0.35	0.75	0.32016	0.25	**Y**	**N**
Curtian Wall Glazing	0.35	0.7	0.32016	0.25	**Y**	**N**

Table 2 – Building Envelope Requirements Compliance

(4.2) Section 6: Heating, Ventilating, and Air Conditioning

The gross floor area of the New Braunfels Regional Rehabilitation Hospital is over 25,000 ft^2; therefore, the compliance will be determined by an analysis of Sections 6.4, Mandatory Provisions and 6.5, Prescriptive Path.

Section 6.4.2: Load Calculations

In accordance with the requirements of this section, the mechanical designer calculated heating and cooling system design loads with ASHRAE standards and professional engineering practices in mind to adequately size equipment and systems.

Section 6.4.3: Controls

Each zone within the facility is individually controlled by temperature sensors within the zone, in compliance with Standard 90.1. In certain areas where proper zone pressurization is integral to the health of the occupants, an override of these temperature controls is provided in the form of a differential pressure sensor.

Section 6.4.4: HVAC System Construction and Insulation

Specification section 230700 notes that the HVAC insulation thickness and R-Values are to comply with ASHRAE Standard 90.1-2004. This specification also states that joint sealants and metal jacket flashing sealants are to comply with local construction requirements.

Section 6.5.1: Economizers

According to Table 6.5.1 of Standard 90.1, there is no economizer requirement for climate zone 2A, though all of the rooftop units are equipped with a 0-100% outside air economizer to take advantage of free-cooling opportunities.

Section 6.5.2: Simultaneous Heating and Cooling Limitation

Section 6.5.2 requires temperature controls that are capable of preventing reheating and cooling to individual zones. VAV-level reheat is included in the mechanical system of this facility, but many of the zones fall under the exception of having special pressurization relationships and cross-contamination requirements, so this section of Standard 90.1 is not applicable.

Section 6.5.3: Air System Design and Control

The fan power limitation requirement outlined in Section 6.5.3 requires fans to comply with Table 6.5.3.1.1A, shown below in Figure 4.

TABLE 6.5.3.1.1A Fan Power Limitation[a]

	Limit	Constant Volume	Variable Volume
Option 1: Fan System Motor Nameplate hp	Allowable Nameplate Motor hp	$hp \le CFM_S \cdot 0.0011$	$hp \le CFM_S \cdot 0.0015$
Option 2: Fan System bhp	Allowable Fan System bhp	$bhp \le CFM_S \cdot 0.00094 + A$	$bhp \le CFM_S \cdot 0.0013 + A$

[a] where
CFM_S = the maximum design supply airflow rate to conditioned spaces served by the system in cubic feet per minute
hp = the maximum combined motor nameplate horsepower
bhp = the maximum combined fan brake horsepower
A = sum of $(PD \times CFM_D/4131)$
where
PD = each applicable pressure drop adjustment from Table 6.5.3.1.1B in in. w.c.
CFM_D = the design airflow through each applicable device from Table 6.5.3.1.1B in cubic feet per minute

Figure 4 – Fan Power Limitation Requirements

A summary of fan compliance calculations is shown in Table B1 of Appendix B. All exhaust fans in the facility were determined to be compliant. The only non-compliant fan was the supply fan serving the IV Prep room.

Section 6.5.4: Hydronic System Design and Control

The total pump system power of the hydronic hot water system is a maximum of 10 HP, which equals, but does not exceed the requirements needed to apply Section 6.5.4.

Section 6.5.5: Heat Rejection Equipment

None of the fans used in the HVAC system is powered by a motor of above 7.5 HP, and thus Section 6.5.5 is not considered in this report.

Section 6.5.6: Energy Recovery

The rehabilitation hospital's mechanical systems do not use any exhaust air heat recovery or service water heat recovery systems, thus Section 6.5.5 is not applicable to this compliance analysis.

Section 6.5.7: Exhaust Hoods

The largest exhaust hood in the facility is for the kitchen exhaust fan, which pulls 3600 CFM. This is not a large enough airflow rate to warrant an analysis of Section 6.5.7.

Section 6.5.8: Radiant Heating Systems

There are no radiant heating systems in the New Braunfels Regional Rehabilitation Hospital. That being said, Section 6.5.8 is inapplicable.

Section 6.5.9: Hot Gas Bypass Limitation

A hot gas bypass system is used in the condensing section of each of the rooftop units. Control of hot gas bypass is factory installed on one of the refrigerant coils for constant capacity control of up to 25%, as specified. This is in accordance with Table 6.5.9 and Section 6.5.9 of ASHRAE Standard 90.1.

(4.3) Section 7: Service Water Heating

Compliance with Section 7 of ASHRAE Standard 90.1 will be determined by Section 7.4, Mandatory Provisions.

Table 7.8 specifies that the minimum performance requirement for gas-fired hot water heating boilers with input between 300 and 12,500 MBH is 80% thermal efficiency. Both hot water boilers used to serve the VAV reheat coils have an 849 MBH output given a 999 MBH input, according to the schedules on the mechanical design drawings. This gives these boilers a thermal efficiency of 85%, complying with this standard.

This standard also requires the water heaters used for domestic water supply to have an 80% thermal efficiency. According to manufacturer's data, these water heaters have a 96% thermal efficiency in compliance with Standard 90.1.

The dehumidification unit that uses rejected heat to maintain pool temperature has a time switch on the unit and fuse disconnect next to the unit, which is in compliance with Section 7.4.5.

(4.4) Section 8: Power

The New Braunfels Regional Rehabilitation Hospital is noted to comply with the latest version of the National Electric Code (NEC) in specification section 260100. The latest version of the NEC requires feeder conductors requires feeder conductors to be sized for a maximum voltage drop of 3% at design load, whereas Section 8.4.1.1 of ASHRAE Standard 90.1 requires feeder conductors to be sized at a maximum of 2% voltage drop at design load.

The power distribution system of the facility does not necessarily comply with Standard 90.1.

(4.5) Section 9: Lighting

The space-by-space method for calculating interior lighting power allowances, as described in Section 9.6.1 of ASHRAE Standard 90.1, was used to determine lighting power density compliance for the facility. The lighting power density was calculated for a sample of rooms and compared to the allowable lighting power density from Table 9.6.1 of Standard 90.1. A summary of these comparisons is shown in Table 3 below.

A majority of the spaces were not compliant with the maximum lighting power density. Several of these rooms have safety and health issues associated with proper lighting, which could account for the high lighting power densities in such areas.

Sample Lighting Power Densities					
Sample Room	Lighting Power (W)	Area (SF)	Lighting Power Density (W/SF)	Required Lighting Power Density (W/SF)	Compliant?
Patient Room	180	214	0.84	0.7	N
Restroom	105	51	2.06	0.9	N
Thearpy Room	90	99	0.91	0.9	N
Exam Room	90	100	0.90	1.5	Y
Admin. Office	180	99	1.82	1.1	N
Hospital Lobby	780	859	0.91	0.8	N
Medical Storage	120	99	1.21	1.4	Y
General Storage	300	419	0.72	0.3	N
Dining Room	1320	1435	0.92	0.9	N
Mechanical Room	180	276	0.65	1.5	Y
Electrical Room	120	106	1.13	1.5	Y
Conference Room	220	119	1.85	1.3	N
Therapy Gym	1770	1829	0.97	0.9	N

Table 3 – Sample Lighting Power Densities

(4.6) Section 10: Other Equipment

Section 10.4.1 of Standard 90.1 states that electric motors shall comply with the minimum nominal efficiencies outlined in Table 10.8 of the standard. Motors associated with the two heating hot water pumps operate at 1750 RPM with a maximum 5 horsepower, with a minimum efficiency of 58%. This is not in compliance with the required minimum full-load efficiency of 87.5% set in place by Standard 90.1.

In the hot Texas climate, these heating hot water pumps will rarely be operating at full load, so meeting a high full-load efficiency for these pumps was likely not a cost-effective design.

(4.7) Standard 90.1 Analysis Conclusions

The requirements of ASHRAE Standard 90.1 were not completely met by the mechanical system design of the New Braunfels Regional Rehabilitation Hospital.

Due to the critical functions of the building, the focus of the mechanical system design was on occupant safety and comfort, so sustainability may have taken a back seat in some areas. Although the facility did not completely comply with the standard and did not strive for LEED Certification, several areas of Standard 90.1 were met and even exceeded with a responsible design in mind.

The building envelope U-Values are well below those required by this standard, even if the shading coefficient of the glazing system did not comply. All exhaust fans met the fan power limitation requirements and air-side economizers are used, though they are not required for this climate region. Domestic and heating hot water equipment also significantly surpasses the minimum efficiency requirements set by Standard 90.1.

Despite not complying entirely with ASHRAE Standard 90.1, the New Braunfels Regional Rehabilitation Hospital meets the occupants' safety and comfort needs with an environmentally conscious design.

Appendix A: Ventilation Rate Calculations

RTU-1 VENTILATION CALCULATIONS

Min OA (CFM): 6850
Total Airflow (CFM): 26000
Outdoor Air Fraction (Z_p): 0.2635

Standard 170 Analysis										
Room Name	Occupancy Category	Total Airflow (Supply/Exhaust) (CFM)	Area (SF)	Height (ft)	Total ACH	Total Outdoor ACH	Minimum Total ACH	Minimum Outdoor ACH	Room Complies?	Required Ventilation Air (CFM)
Corridor	Corridor	550	576	9	6.4	1.7	2	0	Y	0.0
Patient Room	Patient Room	440	215	9	13.6	3.6	6	2	Y	64.5
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	410	214	9	12.8	3.4	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	440	215	9	13.6	3.6	6	2	Y	64.5
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	410	214	9	12.8	3.4	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	440	215	9	13.6	3.6	6	2	Y	64.5
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	410	214	9	12.8	3.4	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	500	215	9	15.5	4.1	6	2	Y	64.5
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	430	214	9	13.4	3.5	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Corridor	Corridor	660	718	9	6.1	1.6	2	0	Y	0.0
Patient Room	Patient Room	440	214	9	13.7	3.6	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	440	214	9	13.7	3.6	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	440	214	9	13.7	3.6	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	440	214	9	13.7	3.6	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	440	214	9	13.7	3.6	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	380	214	9	11.8	3.1	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	380	214	9	11.8	3.1	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	440	214	9	13.7	3.6	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	440	214	9	13.7	3.6	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	440	214	9	13.7	3.6	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	440	214	9	13.7	3.6	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	440	214	9	13.7	3.6	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Corridor	Corridor	680	699	9	6.5	1.7	2	0	Y	0.0
Corridor	Corridor	660	718	9	6.1	1.6	2	0	Y	0.0
Patient Room	Patient Room	420	214	9	13.1	3.4	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	420	214	9	13.1	3.4	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	420	214	9	13.1	3.4	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	420	214	9	13.1	3.4	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Isolation Patient Room	Patient Room	420	214	9	13.1	3.4	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Isolation Patient Room	Patient Room	500	214	9	15.6	4.1	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	380	214	9	11.8	3.1	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	420	214	9	13.1	3.4	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	420	214	9	13.1	3.4	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	420	214	9	13.1	3.4	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	420	214	9	13.1	3.4	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	420	214	9	13.1	3.4	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Corridor	Corridor	340	632	9	3.6	0.9	2	0	Y	0.0
Corridor	Corridor	550	575	9	6.4	1.7	2	0	Y	0.0
Patient Room	Patient Room	410	214	9	12.8	3.4	6	2	Y	64.2

(Table continued on following page)

Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	480	214	9	15.0	3.9	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	410	214	9	12.8	3.4	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	480	214	9	15.0	3.9	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	410	214	9	12.8	3.4	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	480	214	9	15.0	3.9	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	430	214	9	13.4	3.5	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Patient Room	Patient Room	500	214	9	15.6	4.1	6	2	Y	64.2
Toilet	Toilet Room	70	51	8	10.3	2.7	10	0	Y	0.0
Nourishment	Pharmacy	100	103	9	6.5	1.7	10	0	N	0.0
Alcove	Corridor	100	102	9	6.5	1.7	2	0	Y	0.0
Alcove	Corridor	100	103	9	6.5	1.7	2	0	Y	0.0
Assisted Bathing	Bathing Room	150	172	9	5.8	1.5	10	0	N	0.0
IV Prep	Sterilizing	570	78	9	48.7	12.8	10	0	Y	0.0
Pharmacy	Pharmacy	190	183	9	6.9	1.8	4	2	N	54.9
Med Room	Pharmacy	100	102	9	6.5	1.7	4	2	N	30.6
Equipment Storage	Sterile Storage	70	65	9	7.2	1.9	4	2	N	19.5
Toilet	Toilet Room	40	58	8	5.2	1.4	10	0	N	0.0
Toilet	Toilet Room	40	58	8	5.2	1.4	10	0	N	0.0
Clean Linen Supply	Clean Linen	170	190	9	6.0	1.6	2	0	Y	0.0
Soiled Linen Utility	Soiled Linen	200	174	9	7.7	2.0	10	0	N	0.0
Respiratory Storage	Sterile Storage	100	99	9	6.7	1.8	4	2	N	29.7
Body Holding	Body Holding	50	79	9	4.2	1.1	10	0	N	0.0
Restroom	Toilet Room	50	66	8	5.7	1.5	10	0	N	0.0
Corridor	Corridor	340	166	9	13.7	3.6	2	0	Y	0.0
Med Gas Pump Room	Medical Gas Storage	500	188	9	17.7	4.7	0	8	N	225.6
Med Gas Access	Medical Gas Storage	70	99	9	4.7	1.2	0	8	N	118.8
Equipment Storage	Sterile Storage	400	290	9	9.2	2.4	4	2	Y	87.0

Standard 62.1 Analysis

Room Name	Occupancy Category	Total Supply Air (CFM)	Area (SF)	Max Occupants	CFM/SF	CFM/Person	Required Ventilation Air (CFM)
Day Room	Break Room	1120	423	8	0.06	5	65.4
Tele/Data	Equipment Room	800	131	0	0.06	0	7.9
Storage	Storage	200	198	0	0.12	0	23.8
Electrical	Equipment Room	800	123	0	0.06	0	7.4
Office	Office Space	300	252	4	0.06	5	35.1
Office	Office Space	80	79	4	0.06	5	24.7
Office	Office Space	80	78	4	0.06	5	24.7
Nursing Admin	Office Space	80	80	4	0.06	5	24.8
Nursing Admin	Office Space	80	80	4	0.06	5	24.8
Storage	Storage	30	33	0	0.12	0	4.0
Housekeeping	Storage	70	47	0	0.12	0	5.6
Pharmacy Office	Office Space	90	97	4	0.06	5	25.8
Staff Breakroom	Break Room	180	157	2	0.06	5	19.4
Respiratory Office	Office Space	100	101	4	0.06	5	26.1
Housekeeping	Storage	0	56	0	0.12	0	6.7
Storage	Storage	100	97	0	0.12	0	11.6
Nurse Station	Office Space	3840	2355	23	0.06	5	256.3
							3729.4

Table A1: RTU-1 Ventilation Rate Calculation

RTU-2 VENTILATION CALCULATIONS

Min OA (CFM): 2015

Total Airflow (CFM): 12000

Outdoor Air Fraction (Z_p): 0.1679

Room Name	Occupancy Category	Total Supply Airflow (CFM)	Area (SF)	Max Occupants	CFM/SF	CFM/Person	Required Ventilation Air (CFM)
Outpatient Day Treatment	Health/Aerobics	1900	1710	18	0.06	10	282.6
Storage	Storage	50	36	0	0.12	0	4.3
Storage	Storage	50	67	0	0.12	0	8.0
Therapy Gym	Health/Aerobics	4620	1829	18	0.06	10	289.7
Charting	Office Space	500	402	4	0.06	5	44.1
Therapy Reception	Lobby	230	350	0	0.06	5	21.0
Clinical Director	Office Space	100	90	1	0.06	5	10.4
Toilet	Restroom	50	63	0	0	0	0.0
Private Therapy	Office Space	100	101	2	0.06	5	16.1
Housekeeping	Storage	50	49	0	0.12	0	5.9
ADL Suite	Office Space	380	363	1	0.06	5	26.8
Corridor	Corridor	130	188	0	0.06	0	11.3
Locker	Restroom	120	89	0	0	0	0.0
Locker	Restroom	150	105	0	0	0	0.0
Speech Therapy	Office Space	100	112	4	0.06	5	26.7
Speech Therapy	Office Space	100	112	4	0.06	5	26.7
Classroom	Classroom	440	350	18	0.12	10	222.0
Transition Suite	Office Space	500	291	1	0.06	5	22.5
Hallway	Corridor	500	189	0	0.06	0	11.3
Hallway	Corridor	320	389	0	0.06	0	23.3
Reception Coordination	Office Space	150	201	2	0.06	5	22.1
Files	Storage	50	69	0	0.12	0	8.3
Toilet	Restroom	50	52	0	0	0	0.0
Storage	Storage	50	44	0	0.12	0	5.3
Exam	Office Space	120	104	6	0.06	5	36.2
Medical Director	Office Space	80	99	2	0.06	5	15.9
Clinical Director	Office Space	80	99	2	0.06	5	15.9
Hallway	Corridor	150	218	0	0.06	0	13.1
Exam	Office Space	90	100	6	0.06	5	36.0
Emergency Treatment	Office Space	160	813	6	0.06	5	78.8
Waiting	Lobby	160	206	6	0.06	5	42.4
							1326.8

Table A2: RTU-2 Ventilation Rate Calculation

RTU-3 VENTILATION CALCULATIONS
Min OA (CFM): 4550
Total Airflow (CFM): 17500
Outdoor Air Fraction (Z_p): 0.2600

Room Name	Occupancy Category	Total Supply Air (CFM)	Area (SF)	Max Occupants	CFM/SF	CFM/Person	Required Ventilation Air (CFM)
Maint Office	Office Space	190	120	1	0.06	5	12.2
Dry Storage	Storage	190	133	0	0.12	0	16.0
Dietician	Office Space	120	126	1	0.06	5	12.6
Housekeeping	Storage	50	48	0	0.12	0	5.8
Dietary Breakdown Receiving	Storage	100	87	0	0.12	0	10.4
M Staff Toilet	Restroom	150	70	0	0	0	0.0
Dish Wash	Kitchen	300	171	0	0	0	0.0
Kitchen	Kitchen	1800	867	10	0	0	0.0
Serving Line	Cafeteria	790	1021	18	0.18	7.5	318.8
Dining	Cafeteria	3700	1435	88	0.18	7.5	918.3
Day Room	Break Room	700	465	8	0.06	5	67.9
W Staff Toilet	Restroom	150	123	0	0	0	0.0
Vestibule	Lobby	600	145	4	0.06	5	28.7
Lobby	Lobby	750	859	15	0.06	5	126.5
Waiting	Lobby	750	137	2	0.06	5	18.2
Admission	Conference	510	274	10	0.06	5	66.4
Conference Room	Conference	370	265	12	0.06	5	75.9
Restroom	Restroom	200	173	0	0	0	0.0
Restroom	Restroom	200	173	0	0	0	0.0
Hallway	Corridor	400	1328	0	0.06	0	79.7
Conference Room	Conference	450	278	14	0.06	5	86.7
Quality	Office Space	110	109	1	0.06	5	11.5
Marktg	Office Space	100	102	1	0.06	5	11.1
CEO	Office Space	450	147	1	0.06	5	13.8
CFO	Office Space	430	119	1	0.06	5	12.1
Marketing	Office Space	100	94	1	0.06	5	10.6
Workroom	Office Space	330	117	1	0.06	5	12.0
Admin	Office Space	100	338	2	0.06	5	30.3
Business Office	Office Space	540	553	4	0.06	5	53.2
Payroll	Office Space	100	88	1	0.06	5	10.3
BOM Office	Office Space	400	87	1	0.06	5	10.2
Medical Records	Storage	380	88	0	0.12	0	10.6
Medical Records	Storage	550	300	0	0.12	0	36.0
General Storage	Storage	350	419	0	0.12	0	50.3
Mechanical	Equipment Room	240	276	0	0.06	0	16.6
Electrical	Equipment Room	500	106	0	0.06	0	6.4
ATS/Emergency Electric	Equipment Room	370	202	0	0.06	0	12.1
Maintenance Shop	Equipment Room	240	309	0	0.06	0	18.5
Telecom	Equipment Room	500	95	0	0.06	0	5.7
Soiled Linen	Storage	130	59	0	0.12	0	7.1
Storage	Storage	60	71	0	0.12	0	8.5
Corridor	Corridor	400	491	0	0.06	0	29.5
Hallway	Corridor	270	349	0	0.06	0	20.9
Conference Room	Conference	200	119	6	0.06	5	37.1
Files	Storage	50	67	0	0.12	0	8.0
Human Resources	Office Space	150	118	2	0.06	5	17.1
Tray Return	Storage	100	80	0	0.12	0	9.6
							2313.3

Table A3: RTU-3 Ventilation Rate Calculation

Appendix B: Fan Compliance Calculations

Fan Power Limitation Summary				
Fan	CFM	HP	CFM·0.0011	Compliant?
EF-1	700	0.25	0.77	Y
EF-2	1840	0.50	2.02	Y
EF-3	1020	0.33	1.12	Y
EF-4	630	0.25	0.69	Y
EF-5	1070	0.33	1.18	Y
EF-6	300	0.08	0.33	Y
EF-7	1250	0.50	1.38	Y
EF-8	860	0.25	0.95	Y
EF-9	260	0.03	0.29	Y
EF-10	400	0.25	0.44	Y
EF-11	600	0.03	0.66	Y
KEF-1	3600	1.50	3.96	Y
KEF-2	750	0.50	0.83	Y
GEF-1	2000	0.50	2.20	Y
SF-1	570	1.00	0.63	N

Table B1: Fan Power Limitation Summary